

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**  
**BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES**

APPLICANT: Avetik Harutyunyan et al.  
APPLICATION NO.: 10/727,699  
FILING DATE: December 03, 2003  
TITLE: Systems and Methods for Production of Carbon Nanostructures  
EXAMINER: Edward M. Johnson  
GROUP ART UNIT: 1754  
ATTY. DKT. NO.: 23085-07810

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Dated: June 12, 2009

By: / Narinder Banait /

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**REPLY BRIEF**

This Reply Brief is filed in accordance with 37 CFR § 41.41 in response to the  
*Examiner's Answer*, mailed on April 13, 2009.

**Status of Claims**

Claims 1-5, 7, 8, 10-18, and 38-49 are pending and stand finally rejected in a Final Office Action mailed on December 18, 2007. These claims are set forth in an appendix attached hereto.

**Grounds of Rejection to be Reviewed on Appeal**

Whether claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 are unpatentable under 35 U.S.C. §103(a) U.S. Patent No 4,663,230 to Tennent.

Whether claims 4 and 40 are unpatentable under 35 U.S.C. §103(a) over U.S. Patent No 4,663,230 to Tennent further in view of U.S. Patent No. 6,221,330 to Moy *et al.*

**Argument**

The Examiner's Answer mailed on April 13, 2009 is responsive to the Appeal Brief filed on December 18, 2008 appealing from the Final Office Action mailed on December 18, 2007. In the Examiner's Answer, the Examiner restates the rejections set forth in the Final Office Action. The Appeal Brief filed on December 18, 2008 fully addresses the deficiencies of these rejections. Examiner's response to the arguments presented in the Brief is addressed below.

**Rejection of claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 under 35 U.S.C. §103(a)**

In the Answer, at page 5, last paragraph, the Examiner states that Tennent discloses 0.2 and 15 microns in the materials section of the Examples, and it would have been obvious to entrain Tennent's catalyst in inert gas.

An element of the appellant's independent claims 1 and 38 is a catalyst supported on a powdered oxide substrate having a particle size of 0.5  $\mu\text{m}$  to 5  $\mu\text{m}$  and entraining the supported catalyst in an inert gas. Tennent does not teach supporting the catalyst on a powdered oxide substrate nor does it teach entraining the supported catalyst in an inert gas.

The Examiner has misunderstood Tennent, which in fact discloses catalyst nanoparticles placed on a thin film, plate, or a boat. The appellant suggests that a person of skill in the art is not likely to try to entrain Tennent's film, a plate, or a boat made from alumina, carbon, quartz, silicates, and aluminum silicates using an inert gas.

Tennent at column 5, lines 46-53 states:

It is further contemplated that a variety of transition metal-containing particles are suitable as catalysts when used with an appropriate combination of reaction parameters. In a presently preferred embodiment, the metal-containing particle comprises a particle having a diameter between about 3.5 and about 70 nanometers and contains iron, cobalt or nickel, or an alloy or mixture thereof.

Then at column 6, lines 13-22, Tennent discloses:

These catalyst particles may be deposited on chemically compatible, refractory supports. Such supports must remain solid under reaction conditions, must not poison the catalyst, and must be easily separated from the product fibrils after they are formed. Alumina, carbon, quartz, silicates, and aluminum silicates such as mullite are all suitable support materials. For ease of removal, their preferred physical form is thin films or plates which can easily be moved into and out of the reactor.

Thus, Tennent's catalyst are metal or alloy particles having a diameter between about 3.5 and about 70 nanometers and deposited on thin films or plates. Tennent's catalyst do not make obvious the appellant's claim element reciting a catalyst supported on a powdered oxide substrate having a particle size of 0.5  $\mu\text{m}$  to 5  $\mu\text{m}$ .

Further, Tennent in Examples 11-33 discloses the synthesis of the fibrils. In all of these examples, the catalyst is transferred to a refractory support which is then placed in the reaction chamber; the catalyst is not entrained in an inert gas by Tennent. For example, Example 11 states that the “[c]atalyst prepared according to the method of Example 1 was ultrasonically dispersed in water and transferred to a ceramic boat. The boat was placed in the center of a 1” Vycor™ tube in an electric furnace at room temperature.” Thus, the catalyst is placed in a ceramic boat, and not supported on a powdered oxide substrate as claimed by the appellant. The appellant suggests that a ceramic boat containing the catalyst or a 1” Vycor™ tube into which the ceramic boat is placed would be too heavy to be entrained in a gas.

In the Examiner’s Answer, at page 7, 2<sup>nd</sup> full paragraph, the Examiner stated that the appellant’s argument regarding the claim element of forming single-walled carbon nanotubes was not persuasive “because Applicant appears to admit that nano-sized carbon fibers are disclosed, which would at least suggest, to an ordinarily skilled artisan, single walled nanotubes.”

The structure of Tennent’s nano-sized carbon fibrils and appellant’s single-walled carbon nanotubes (SWNTs) is completely different and one of skilled in the art would completely disagree with the Examiner’s position. Tennent at column 4, lines 48-56, defines carbon fibril as “substantially constant diameter between about 3.5 and about 70 nanometers, a length greater than about  $10^2$  times the diameter, an outer region of multiple layers of ordered carbon atoms and a distinct inner core region, each of the layers and core disposed concentrically about the cylindrical axis of the fibril” (emphasis added). Thus, Tennent’s product has multiple layers around an inner core. In contrast, the appellant defined “single-walled carbon nanotube” at

paragraph 22 of his specification as a cylindrically shaped thin sheet of carbon atoms having a wall consisting essentially of a single layer of carbon atoms, and arranged in an hexagonal crystalline structure with a graphitic type of bonding. Thus, Tennent carbon fibrils are structurally different from the SWNTs claimed by the appellant.

Further, Tennent was filed on December 6, 1984, while Iijima's and Bethune's group working independently are credited with discovering SWNTs in 1993. Their discovery has been universally praised because SWNTs possess remarkable mechanical, electronic and magnetic properties. Thus, the views expressed by the scientific community directly contradict Examiner's position where nano-sized carbon fibers are said to at least suggest SWNTs.

Thus, Tennent does not disclose all the elements of the appellant's claims. Therefore, a prima facie case of obviousness is not made. The rejection of claims 1-3, 5, 7, 8, 10-18, 38-39, and 41-49 cannot stand.

#### Rejection of Claims 4 and 40

In the Answer, at page 7, line 17 to the end of page 8, the Examiner stated that the appellant's argument that Moy teaches away from combining it with the teachings of Tennent "appears dubious." The Examiner stated: "Appellant appears to equate the teaching of unsupported catalysts to a teaching that Tennent should be avoided."

As the appellant had previously pointed out, the disclosure of Moy explicitly and directly contradicts the Examiner's position.

Moy at column 2, lines 65-67 states that “supported metal catalysts are inherently disadvantageous, as the support is necessarily incorporated into the single-walled carbon nanotube formed therefrom.” Further, at column 4, lines 4-5, Moy states that their method to form single-walled carbon nanotubes uses unsupported catalysts. Thus, Moy teach away from using the supported catalysts claimed by the appellant to synthesize single-walled carbon nanotubes. Therefore, a skilled artisan would not be motivated to combine Tennent with Moy.

The rejection of claims 4 and 40 cannot stand.

**Summary**

For the foregoing reasons, Appellants respectfully submit that the rejection of claims 1-5, 7, 8, 10-18, and 38-49 is clearly erroneous. Reversal of the final rejection of claims 1-5, 7, 8, 10-18, and 38-49 is respectfully requested.

Respectfully submitted,

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**Claims Appendix**

1. A method for synthesizing carbon nanostructures, the method comprising:  
providing a catalyst of metal nanoparticles, wherein the catalyst is supported on a powdered oxide substrate having a particle size of 0.5  $\mu\text{m}$  to 5  $\mu\text{m}$ ;  
entraining the catalyst in an inert gas; and  
exposing the entrained catalyst to a carbon precursor gas at a temperature sufficient to form carbon nanostructures, wherein the carbon nanostructure is single-walled carbon nanotubes.
2. The method of claim 1, wherein the catalyst is a metal selected from the group consisting of iron, nickel, molybdenum and cobalt, or mixtures thereof.
3. The method of claim 2, wherein the metal is iron.
4. The method of claim 2, wherein the metal is molybdenum.
5. The method of claim 1, wherein the catalyst has a particle size between 3 nm to 7nm or about 5 nm to 10 nm.
7. The method of claim 6, wherein the powdered oxide substrate is selected from the group consisting of  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{MgO}$  and zeolites.
8. The method of claim 7, wherein the powdered oxide substrate is  $\text{Al}_2\text{O}_3$ .
10. The method of claim 1, wherein the inert gas is selected from the group consisting of argon, helium, nitrogen, or hydrogen.
11. The method of claim 10, wherein the inert gas is argon.

12. The method of claim 1, wherein the carbon precursor gas is selected from the group consisting of methane, ethane, propane, ethylene, propylene, and carbon dioxide.
13. The method of claim 12, wherein the carbon precursor gas is methane.
14. The method of claim 1, further comprising another gas.
15. The method of claim 14, wherein the other gas is selected from the group consisting of hydrogen, helium, argon, neon, krypton and xenon or a mixture thereof.
16. The method of claim 15, wherein the other gas is a mixture of hydrogen and argon.
17. The method of claim 1, wherein the temperature is less than 1000 °C.
18. The method of claim 17, wherein the temperature is about 800 °C to 1000 °C.
38. A carbon nanotube structure produced by the process of :  
    entraining a catalyst in an inert gas, wherein the catalyst is a metal supported on a powdered oxide substrate, wherein the metal is selected from the group consisting of iron, nickel, molybdenum and cobalt, or mixtures thereof, and the powdered oxide substrate selected from the group consisting of  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{MgO}$  and zeolites;  
    exposing the entrained catalyst to a precursor gas at a temperature sufficient to form carbon nanotube structure; and  
    collecting the synthesized carbon nanostructures, wherein the carbon nanostructure is single-walled carbon nanotubes.
39. The process of claim 38, wherein the metal is iron.
40. The process of claim 38, wherein the metal is molybdenum.
41. The process of claim 38, wherein the powdered oxide substrate is  $\text{Al}_2\text{O}_3$ .
42. The process of claim 38, wherein the powdered oxide substrate has a particle size of 0.5  $\mu\text{m}$  to 5  $\mu\text{m}$ , and the metal has a particle size between 3 nm to 10 nm.



43. The process of claim 38, wherein the inert gas is selected from the group consisting of argon, helium, nitrogen, or hydrogen.
44. The process of claim 43, wherein the inert gas is argon.
45. The process of claim 38, wherein the reactant gas is selected from the group consisting of methane, ethane, propane, ethylene, propylene, and carbon dioxide.
46. The process of claim 45, wherein the reactant gas is methane.
47. The process of claim 45, further comprising another gas selected from the group consisting of hydrogen, helium, argon, neon, krypton and xenon or a mixture thereof.
48. The process of claim 47, wherein the other gas is a mixture of hydrogen and argon.
49. The process of claim 38, wherein the temperature is less than 1000 °C.